EVALUATION OF OPTIMUM FIBER LENGTH OF BAMBOO FIBER REINFORCED CONCRETE

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRACT

This research deals with the experimental study of the behavior of bamboo fiber with different fiber lengths and to study its effect as fiber reinforcing material. The species of bamboo that used throughout this experiment are the same species which is *Gigantochloa scortechinii* or commonly known as *buluh semantan*. The raw bamboo is delivered from the bamboo grove in Raub, Pahang which supplied by the local. The extractions of fiber are done based on the combined technique of chemical and mechanical using only 10% of w/v of sodium Hydroxide throughout the treatment process. In order to determine the bamboo physical and mechanical properties, a series of physical and mechanical test are done throughout this experiment and the composite samples are being mechanically tested in 3, 7, 14, and 28 days. The tests that has been conducted are bamboo water absorption test, compression and flexural tests. A total of 15 samples of concrete cubes and beams respectively are prepared including the control samples of 3 for each experiment groups for mechanical test. The cube sample and beam sample size used in this research are 100 mm x 100 mm x 100 mm and 100 mm x 100 mm x 500 mm respectively. Based on the results, it shows that the bamboo fiber in overall has only little contribution towards the improvement of concrete strength but significantly enhanced the concrete beam flexural strength which maximum up to 15%. The increase of fiber length leads to the increment of flexural strength but when it exceeds 38 mm, the performance decreased. Hence, it can be concluded that the optimum length for bamboo fiber reinforced concrete is 38mm.

ABSTRAK

Laporan kajian ini membincang tentang kelakuan serat buluh dengan panjang serat yang berlainan dan mengkaji kegunaannya sebagai bahan tetulang serat. Spesies buluh yang digunakan sepanjang eksperimen ini adalah spesies yang sama iaitu Gigantochloa scortechinii atau biasa dikenali sebagai buluh semantan. Buluh mentah didapati dari dusun buluh di Raub, Pahang yang dibekalkan oleh petani tempatan. Pengekstrakan serat dilakukan berdasarkan teknik gabungan kimia dan mekanikal dengan menggunakan hanya 10% w / v Natrium Hidroksida (NaOH) sepanjang proses rawatan. Untuk menentukan ciri fizikal dan mekanikal buluh, ujian fizikal dan mekanikal telah dilakukan sepanjang kajian ini dan sampel komposit telah diuji secara mekanikal dalam 3, 7, 14, dan 28 hari. Ujian yang dijalankan adalah ujian penyerapan air buluh, ujian mampatan dan ujian lenturan. Sejumlah 15 sampel kiub dan rasuk konkrit masing-masing disediakan termasuk 3 sampel kawalan bagi setiap kumpulan eksperimen untuk ujian mekanikal. Sampel kiub dan sampel rasuk yang digunakan dalam kajian ini adalah 100 mm x 100 mm x 100 mm dan 100 mm x 100 mm x 500 mm masing-masing. Berdasarkan hasilnya, ia menunjukkan bahawa serat buluh secara keseluruhannya hanya memberikan sedikit sumbangan terhadap penambahbaikan kekuatan konkrit tetapi peningkatan kekuatan lenturan rasuk konkrit boleh sampai sehingga 15%. Peningkatan dalam kepanjangan serat buluh membawa kepada kenaikan kekuatan lenturan konrit tetapi apabila ia melebihi 38mm, prestasi ia menurun. Oleh itu, dapat disimpulkan bahawa penemuan kami menunjukkan bahawa kepanjangan optimum untuk konkrit bertetulang serat buluh ialah 38 mm.

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LIST OF SYMBOLS

a	*Average distance between line of fracture and the nearest support measured on the tension surface of the beam*
A	*Average cross-sectional area of the specimen*
b	*Average width of specimen*
d	*Average depth of specimen*
D	*Diameter of specimen*
f_c	*Compressive strength of concrete specimen*
L	*Length of specimen*
P	*Maximum load applied*
R	*Flexure strength*
T	*Tensile strength*

LIST OF ABBREVIATIONS

ASTM	*American standard testing methods*
BFc	*Bamboo fibre cotton*
BS	*British standard*
CAN	*Chemical assisted natural*
CMT	*Compressive moulding technique*
FRC	*Fibre reinforced concrete*
N	*Normality*
OPC	*Ordinary Portland cement*
RMT	*Roller mill technique*
SFRC	*Steel fibre reinforced concrete*
TFA	*Trifluoroacetic acid*

CHAPTER 1

INTRODUCTION

1.1 Research Background

Concrete has the benefits such as low costs, high in availability, able to support for large compressive loads is now being the most common material used in construction. However, the normal concrete itself is low in tensile strength, ductility, and low resistance to cracking (Compendex, Elsevier and Services-usa, 2016). Micro cracks are always found in internal of concrete and because of the propagation of such micro cracks, the concrete experience in poor tensile strength as it making concrete become more brittle in fraction. In normal structural concrete and other similar brittle material, structural crack or called micro crack was already developed before any loading applied which is due to drying shrinkage or other causes of volume change happens to the concrete. Hence, to overcome these problems, the alternate ways such as fibre reinforced concreting method has been used. Fibre reinforced concrete is composite concrete that contained fibres, whether in orderly or randomly distributed manner in the cement matrix. Its efficiency of fibre to transfer the stress between the matrix is highly depended on the type of fibre, geometry of fibre, fibre volume and its distribution, mixing and compaction techniques of concrete as well and the size and shape of the aggregates used in the mix would define fibre reinforced concrete properties.

The used of fibres in the concrete mix as a reinforcing material was first recorded with Egyptians mixing straw and hairs of animal in the concrete as a reinforcing material for fixing of bricks in walls (Mahesh and Kavitha, 2016). After decades of research and improvement, steel fibre and synthetic fibre are now widely used as the fibre reinforced material in concrete. However, although high tensile strength of steel are used to complement the low tensile strength problem of concrete, but due to its high in cost and high energy consumption in manufacturing process making the use of steel to be limited

(C. Zhang et al., 2013). Thus, in response to the global warming issues and due to the global concern and emphasising on sustainable society especially for developing country, a more suitable material replacement with a lower cost, environmental friendly and also less energy consuming is needed. (Brindha et al., 2017).

While in current era of industrialization, as people are now tending to give more and more attention to the non-polluting materials and manufacturing process with less energy requirements (Zhang, Pan and Yang, 2012). A lot of research had made and found that there are many useable natural fibres which can work as reinforcement material such as sisal, jute, coir, kenaf, oil palm fibre, sugarcane and others (Ramaswamy, Ahuja and Krishnamoorthy, 1983). However, by addressing all these problems, bamboo was found by contained great potential to become one of the useful material as fibre reinforcement in concrete that can use in constructions with low cost implementation as bamboo is natural, cheap, widely available (Ahmad et al., 2014) and its having mechanical properties such as high tensile strength and high strength to weight ratio which had made bamboo a natural engineering material itself (Mehra et al., 2016).

In this research, mechanical performance of bamboo fibre reinforced concrete are studied through a series of compression and flexural tests. Comparative test was made to find out the impact of the bamboo fibre towards the concrete’s mechanical performance by acquiring the aspect ratio of bamboo fibre compare with plain concrete.

1.2 Problem Statement

Fibre reinforced concrete, which now is a common used construction material. Steel fibre are the most popular to be used in the concrete due to its ability to strengthen its concrete mechanical properties and control cracks development. Although addition of steel fibre in concrete can reduce micro cracks development but through a long period, various if action can corrode the steel causing it to lose of strength and bonding capability in concrete and this lead to the insight on the usage of organic and inorganic fibres which are eco-friendly and economic.

Main reason for people to start considering adding natural fibres in the concrete is due to the extremely high cost steel fibre. (Zhang, Huang and Chen, 2013). Other than high cost of raw material and the production itself, the production of steel fibre required a lot of energy consumption and the process itself contribute significant of greenhouse gases emission, eventually enhanced global warming process and leads to global concern on this issue (Mehra *et al.*, 2016).

Nowadays, people are more concern being in term of sustainability in various aspects. World Commission on Environment and Development (WCED) defined the meaning of sustainability as meeting the needs of the present without compromising the ability of future generations to meet their own needs (Onuaguluchi and Banthia, 2016). Increasing of world population and the pressure associated with the built environment has become one major problem that the mankind is facing. Significant waste generation, energy and material consumption were found as the aftereffect of high demands for building infrastructure by the industry. Therefore, the selection of materials used in construction became more important as it will directly affect to the environment issue raised. Therefore, the reasons for doing research on natural fibre has become a vital part to enhance the sustainability of material used in construction and reduce the impact to the environment.

According to the studies on natural fibres and steel fibres, natural plant fibres was found to be much more in term of renewable, eco-friendly, economical and very low in production cost (Phong *et al.*, 2011). For this research, bamboo fibre had been chosen to be studied as it has high strength to weight ratio and some of its engineering properties of material itself might able be able to use as alternative reinforcing material other than steel and synthetic fibre considering also the cost and availability issue. Hence, a study on bamboo fibres with different proportions of fibre-cement ratio and aspect ratio of are being compared with respect to plain concrete to understand its behaviour and mechanical effect in concrete.

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